Performance of Residential Smoke Alarms Preliminary Results

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Preliminary Analysis
Tenability Limits

- Original work in mid-70's predated significant research on human tenability (see Appendix D of 1975 report for discussion)
  - Temperature = 65°C (150°F)
  - OD = 0.23 m^{-1} at 5 ft
  - CO ≥ 400 ppm (only reached in 2 cases)
- In the 80's combustion toxicology research was based on lethality of test animals (HAZARD I)
  - $FED_{gases} = 5(CO-1700)/4(100000-CO_2) \, \Delta t$
  - $FED_{gases} = 1.0$ lethality, 0.5 incapacitation
  - Included in this analysis with $FED_{gases} = 0.3$ to be consistent with ISO/TS 13571

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Preliminary Analysis
Tenability Limits

- Today the accepted approach is documented in ISO/TS 13571 (and SFPE Handbook of FP Eng) and is based on Purser's incapacitation analysis

  - $FED_{gases} = \Sigma\, CO/35000\ \Delta t$ (times $e^{CO2/5}$ if $CO_2 > 2\%$)

  - $FED_{heat} = \Sigma\, 5*10^7\, T^{-3.4}\, \Delta t$

  - $OD = 0.25\ m^{-1}$ at 5 ft (but NOT 0.5 at 3 ft)

  - $FED = 0.3$ at incapacitation

Preliminary Analysis
Number, Location, Type

- Code requirements
  - Every level (hall outside br), current for existing homes
  - Every level + bedrooms (added for new homes in 1993 based on audibility in bedrooms with doors closed)
  - Every room (heat and sprinkler always in fire room)

- Data for escape time provided, by type (ion, photo, aspirated, heat detector, sprinkler)

- Escape time = Tenability time – Alarm time

- Alarm time for analog based on output voltage and associated unmodified sample response

Preliminary Analysis
Escape Times (min) Every Level
bottom numbers exclude "intimate"

	Photo	Ion	Heat	Sprink
Flaming	.8	1.7	-3.4	-.5
	1.5	2.5	-2.9	.3
Smold	18.3	-12.4	-48.9	-22.4
	32.8	2.2	-15.4	-7.8
Grease	7.5	12.3	-4.7	-3
	11.3	16.2	-.3	0

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Preliminary Analysis

Escape Times (min) Every Level + Bedrooms
bottom numbers exclude "intimate"

	Photo	Ion	Heat	Sprink
Flaming	1.6	1.9	-3.4	-.5
	2.4	2.7	-2.9	.3
Smold	27.4	-11.6	-48.9	-22.4
	41.9	3	-15.4	-7.8
Grease	8.8	12.9	-4.7	-3
	12.6	16.8	-.3	0

Preliminary Analysis
Escape Times (min) Every Room
bottom numbers exclude "intimate"

	Photo	Ion	Heat	Sprink
Flaming	1.6	2.1	-3.4	-.5
	2.9	2.9	-2.9	.3
Smold	30	-11.1	-48.9	-22.4
	44.5	3.5	-15.4	-7.8
Grease	9.6	12.9	-4.7	-3
	13.4	16.8	-.3	0

Preliminary Analysis
Observations

- Escape times are generally shorter than 25 yrs ago
  - More conservative tenability criteria
  - Faster fire development times
    - Average tenability times for smoldering reduced from 72 to 53 minutes and for flaming 17 to 3 minutes

- Ions fail in some smoldering tests

- Sprinklers operate consistently after smoke but would terminate fire and improve conditions

- Heat detectors provide protection for flaming fires but not for smoldering

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